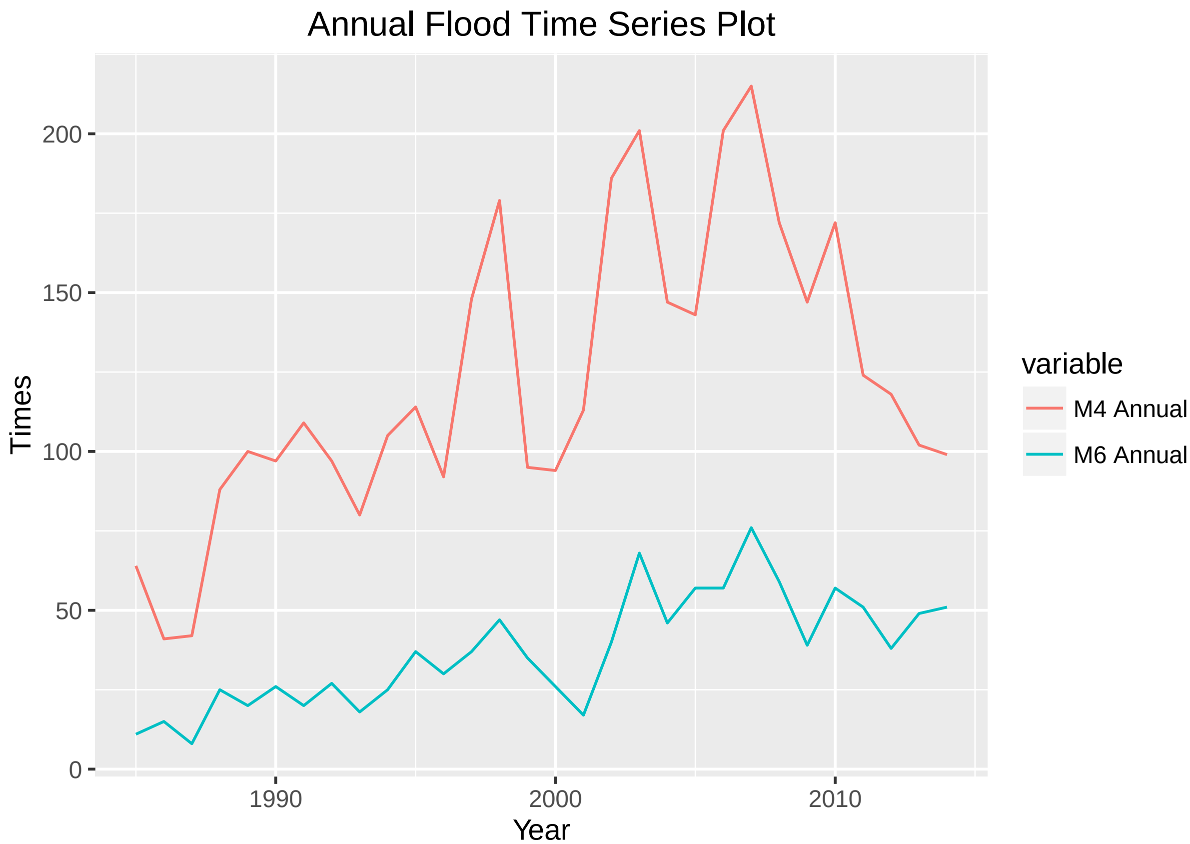
Flood Distribution and The Impact of Atmosphere Pressure

Art of Ark

March 8, 2016

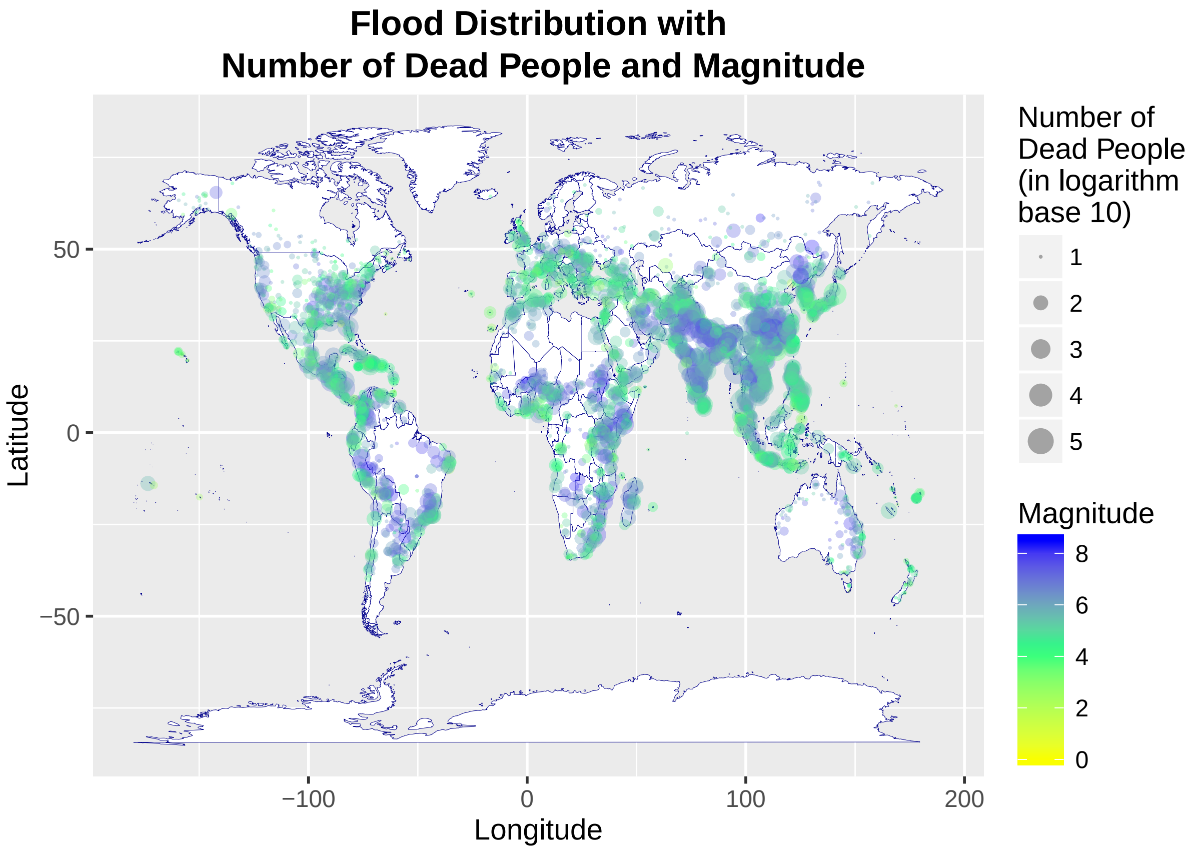
Time Series Plot of Floods



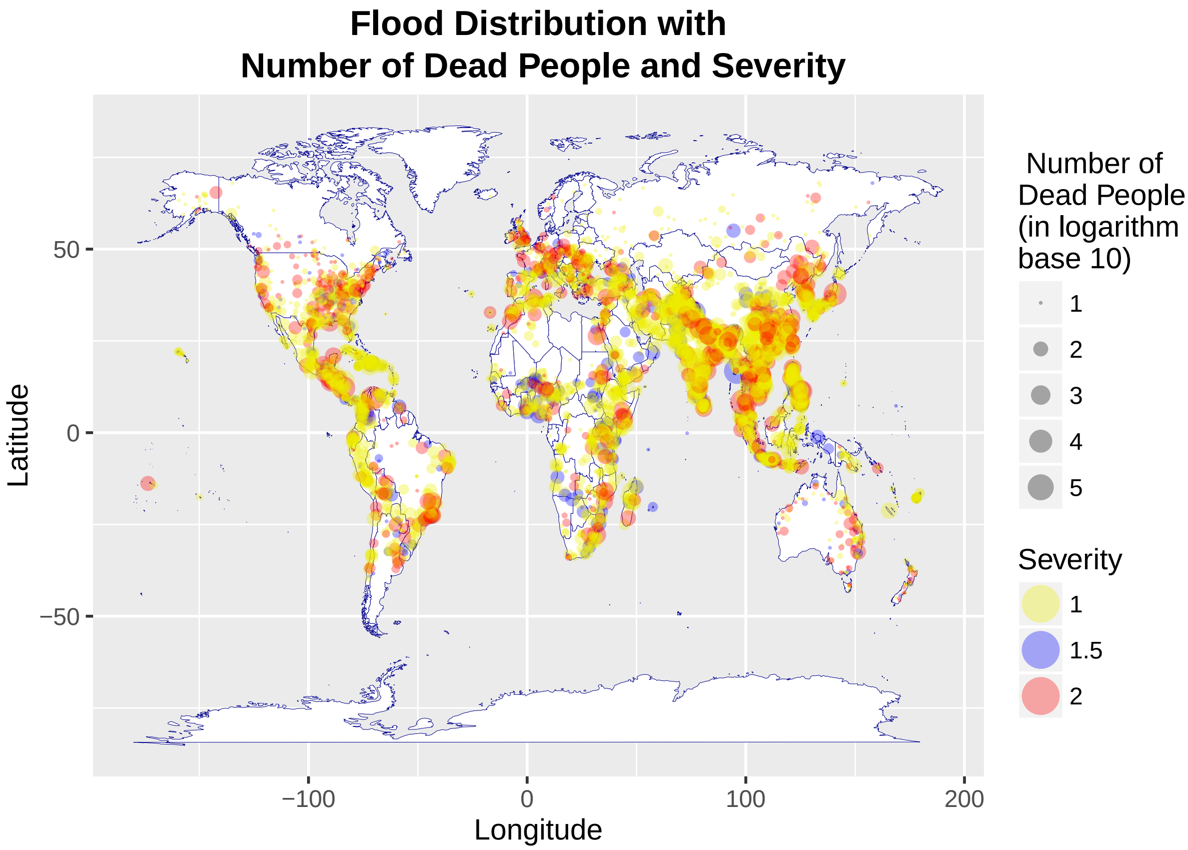
We can see a greater flucuation in the number of M4 floods than M6 floods, and the occurrences of floods of both degrees are highly correlated. After a view of the distribution of floods in time, we will present the spatial distribution.

Spatial Distribution of Floods

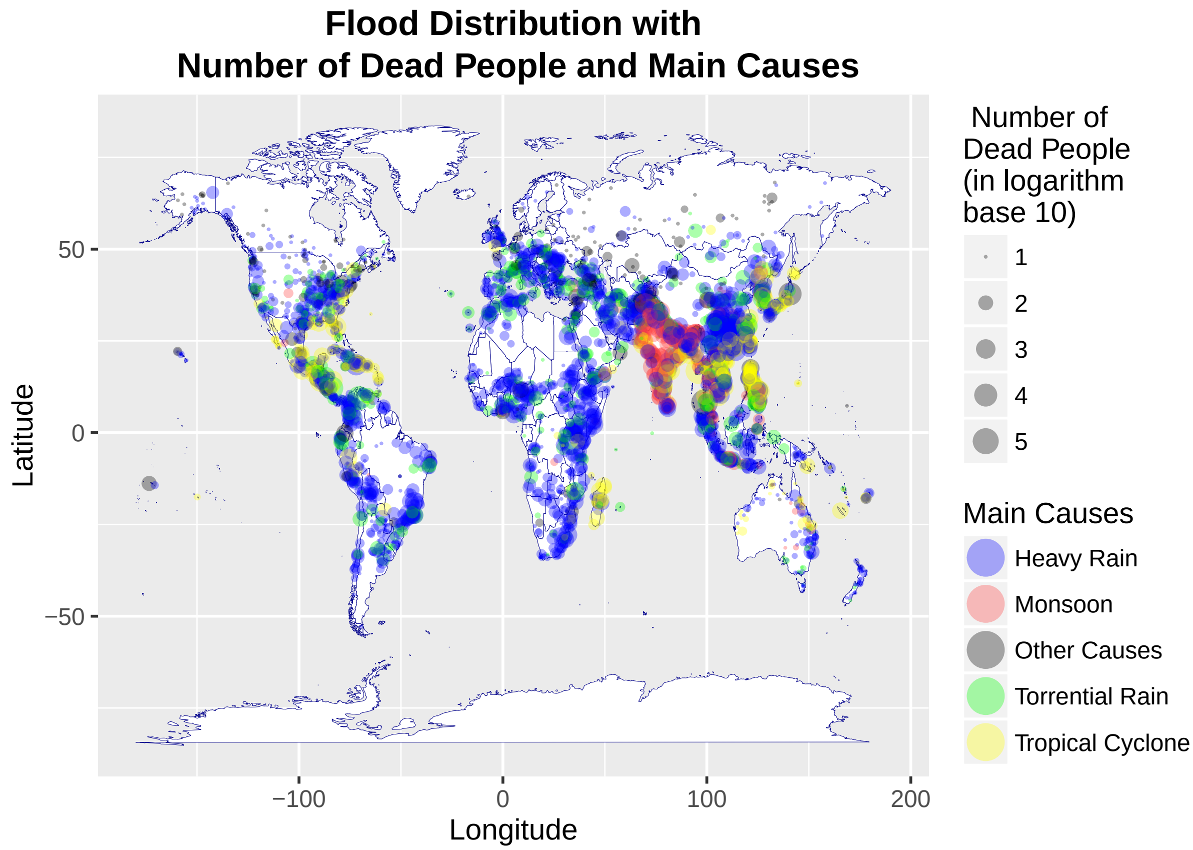
We preprocessed data by identifying the top 4 main reasons among these 10 causes based on some key words. Then we made the following plots among different variables to describe the various spatial distribution of these floods. (For some variables, we took the logarithmic transformation to make it more convenient to watch)



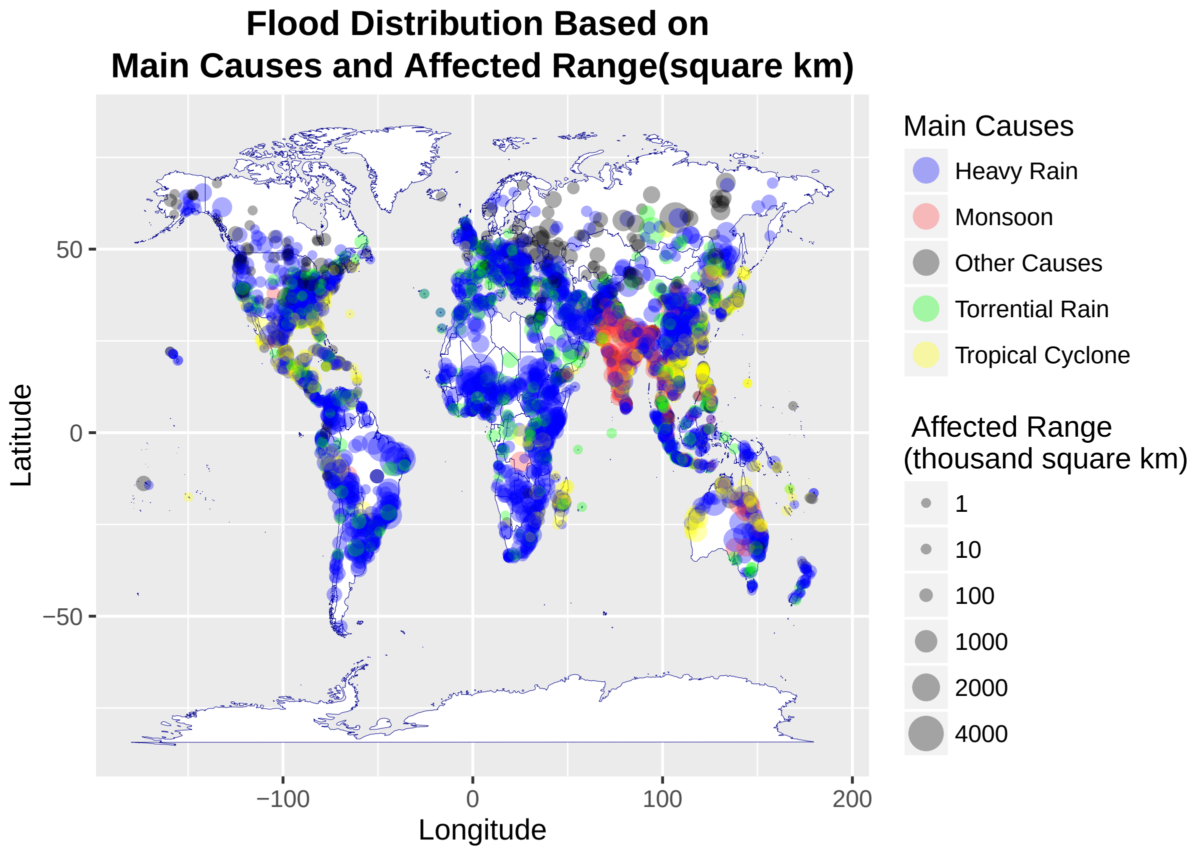
From this distribution plot, combining the magnitude and the number of deaths, we can learn that the floods in East Asia and South Asia had both higher magnitude and larger number of deaths. Specifically, in Malaysia and Thailand, there were several highly serious floods, which resulted in over one hundred thousand people losing their lives. Besides, the East US and Europe also had comparatively more floods with lower magnitude. However, in the southeast coast of South America, the floods suffered from higher magnitudes on average.



From this distribution plot, combining the severity and the number of deaths, we can see that Europe had the densest floods with high severity. Compared to these, the floods in Asia had higher densities but lower severity. But still, the most serious flood around Malaysia had the most severity and the largest number of deaths at the same time. We also notice that in other places like Russia and Africa, the floods had the lowest severities.

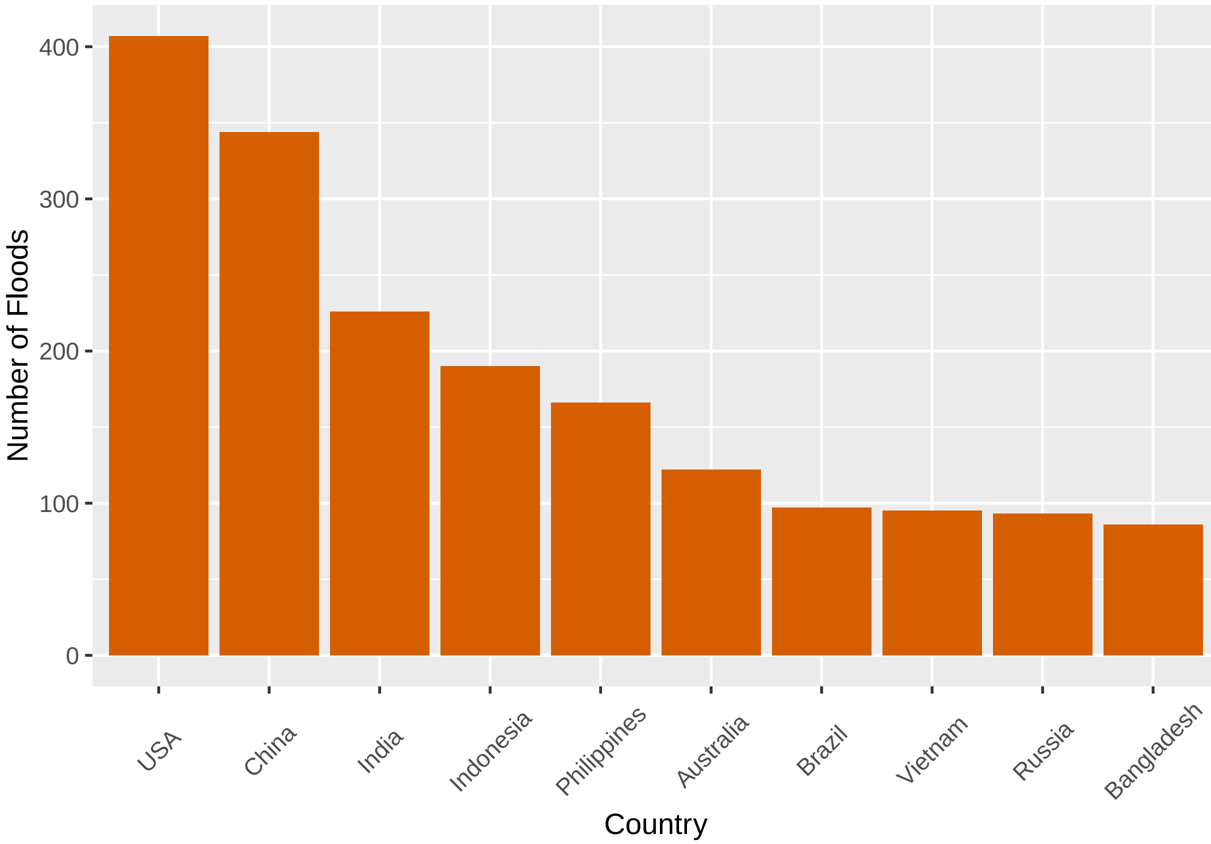


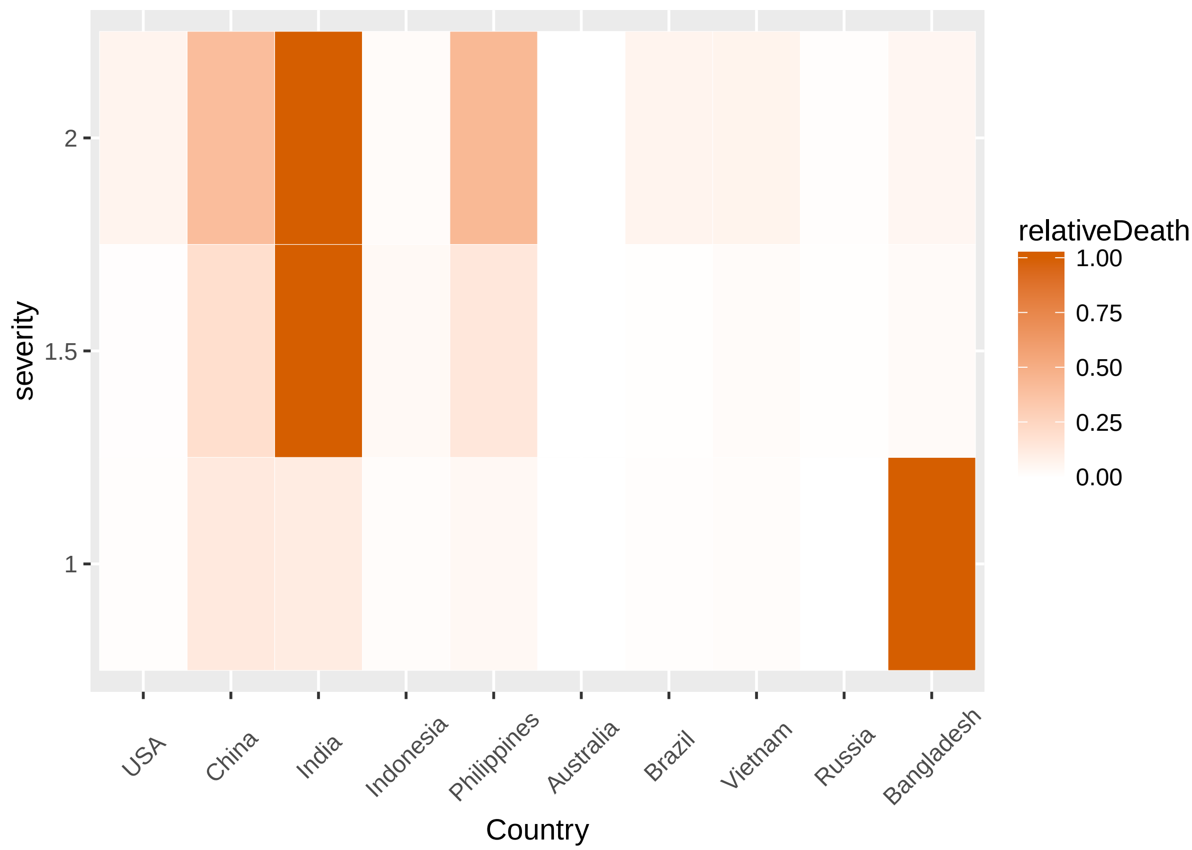
This time, we analyze the relationship between the main reasons behind these floods and the number of deaths. From the corresponding distribution plot, the following conclusions can be drawn. Firstly, the most common reason in the whole wide world is Heavy Rain, especially in Africa. Then, we find the floods in India mostly resulted from Monsoon, which seems to be the exclusive reason. Besides, the floods cased by tropical Cyclone were concentrated on the South Asia and South US. The dense floods in Europe were caused by a combination of Heavy Rain, Torrential Rain and other reasons. As for the floods in Russia, the reasons behind them seems to be uncommon, at least compared to other places.



In the end, we compare the distributions between the main causes and the affected range (square kilometer). From the picture, we can see that the floods in India caused by Monsoon seem to have the one of largest affected scopes. Besides, the causes behinds the intensive floods in South Asia were highly complicated, leading to comparatively small affected ranges with surprise. For example, the most terrible flood in Malaysia that we've discussed seems to have an unexpected small range. The situations of East China and East US seem to be similar: large affected ranges and various reasons behind these dense floods. On the top of these coast areas, the floods in Russia mainland also had large affected ranges.

Floods in Several Countries

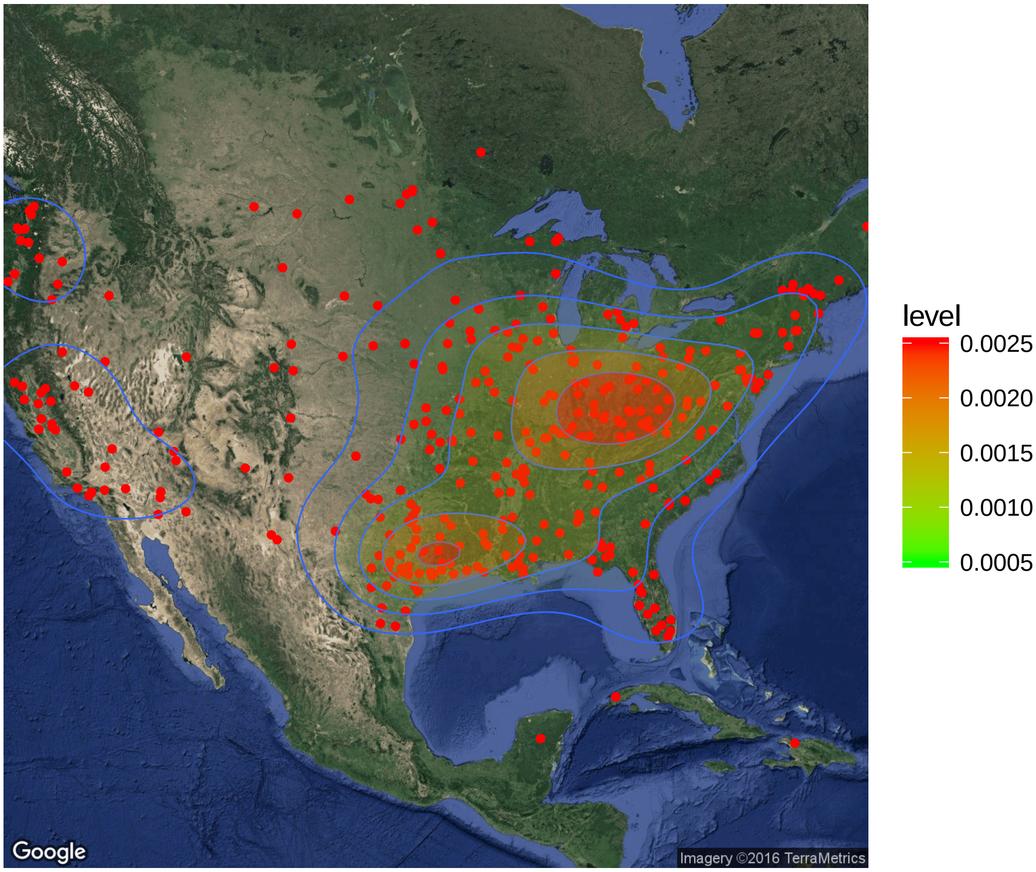




As we can see, USA, China and India are the top three frequently impacted countries. In the next part, we will have a more detailed look into the distributions of floods happened in the three countries. And from the heatmap of the relative death (rescaled by the most death occurred in a certain severity), we can see that USA did a great job in preventing death in floods while India and Bangladesh did not.

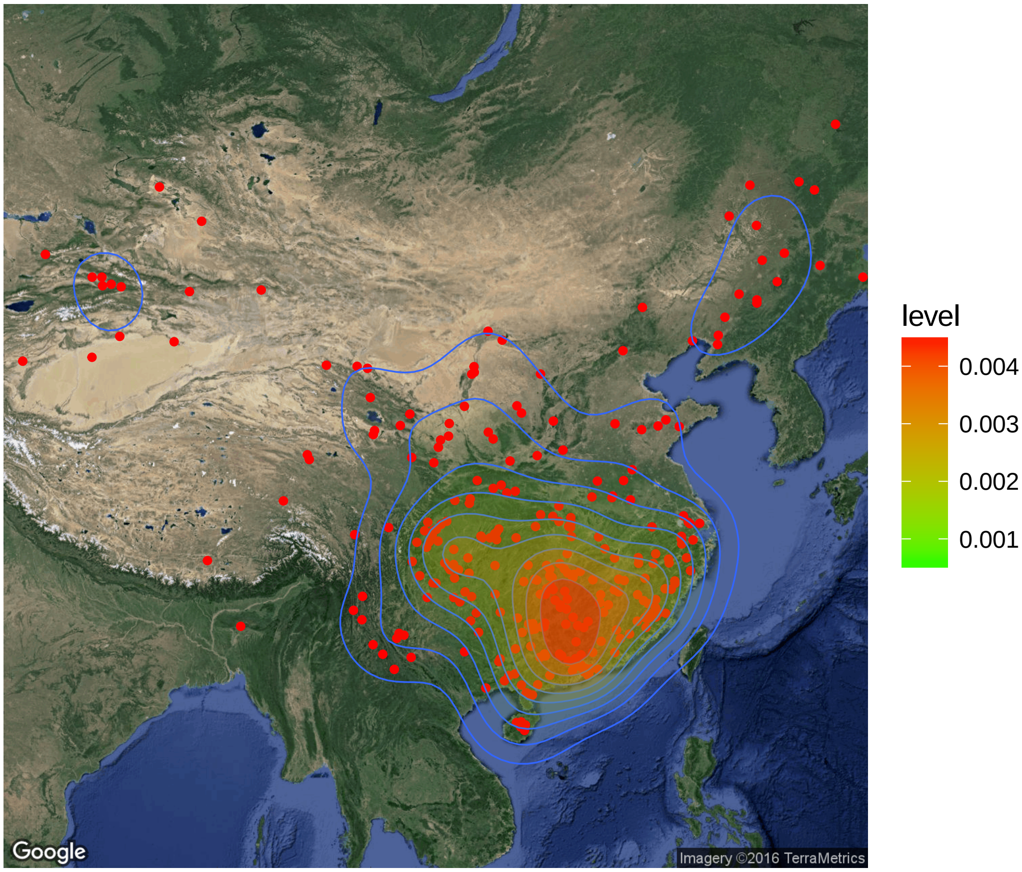
Here, we will describe distribution of floods in USA, China and India.

Firstly, we will draw a case of USA.



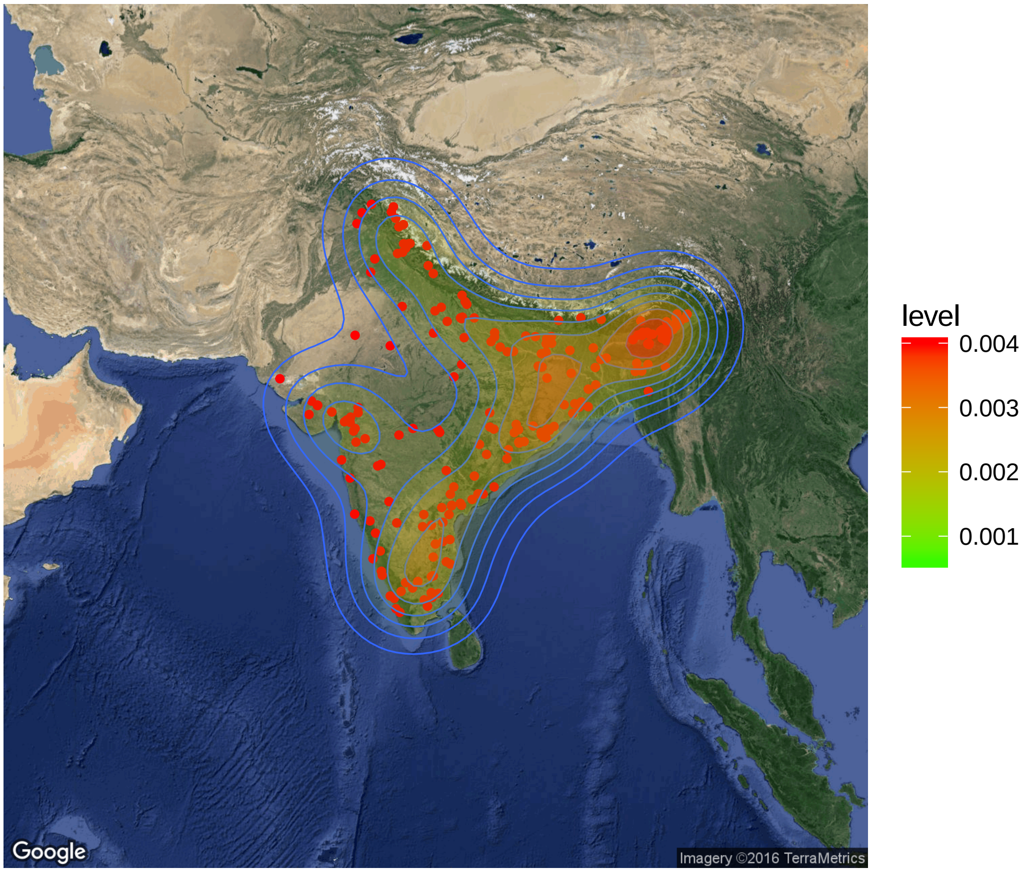
We draw contours based on where floods happened in the past. At the areas which have red color, they had floods many times. As the color turns green, the numbers of floods occurrence decrease. In the case of USA, floods often happened at coastlands. Also, we can see that floods often happened at the middle east area.

Secondly, we will draw a case of China.



In the same way as USA, floods often happened at coastlands in China. We can see that at the area of south east, floods frequently happened.

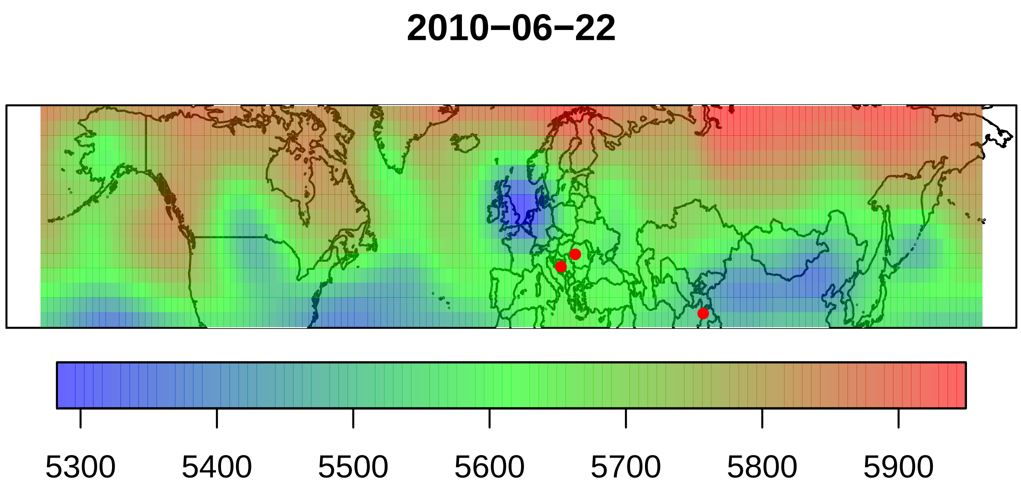
Thirdly, we will draw a case of India.

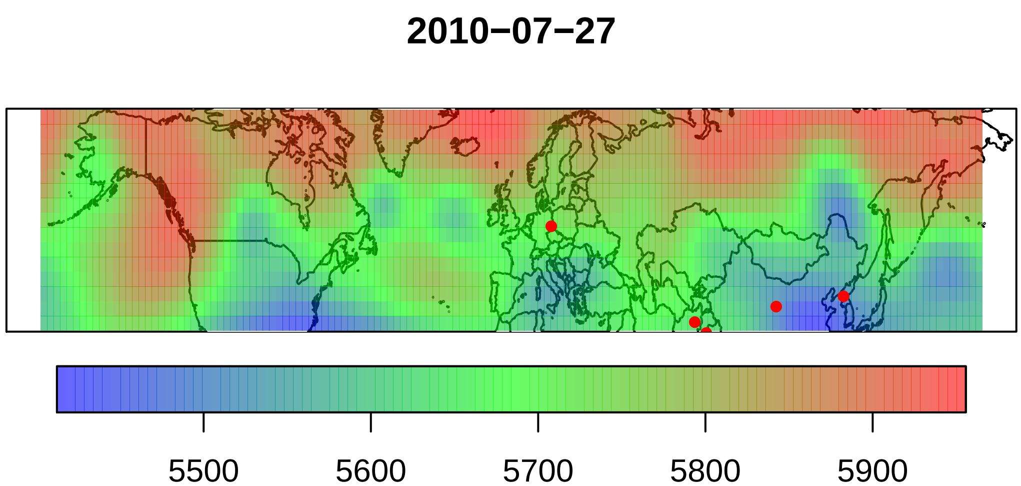


We can see that floods often happened at coastlands in India, and at east area of India, floods frequently happened as well.

Pressure Distribution of Days With More than 4 Floods

We selected several days with the most occurrences of floods and ploted the distribution of the pressure of given area.

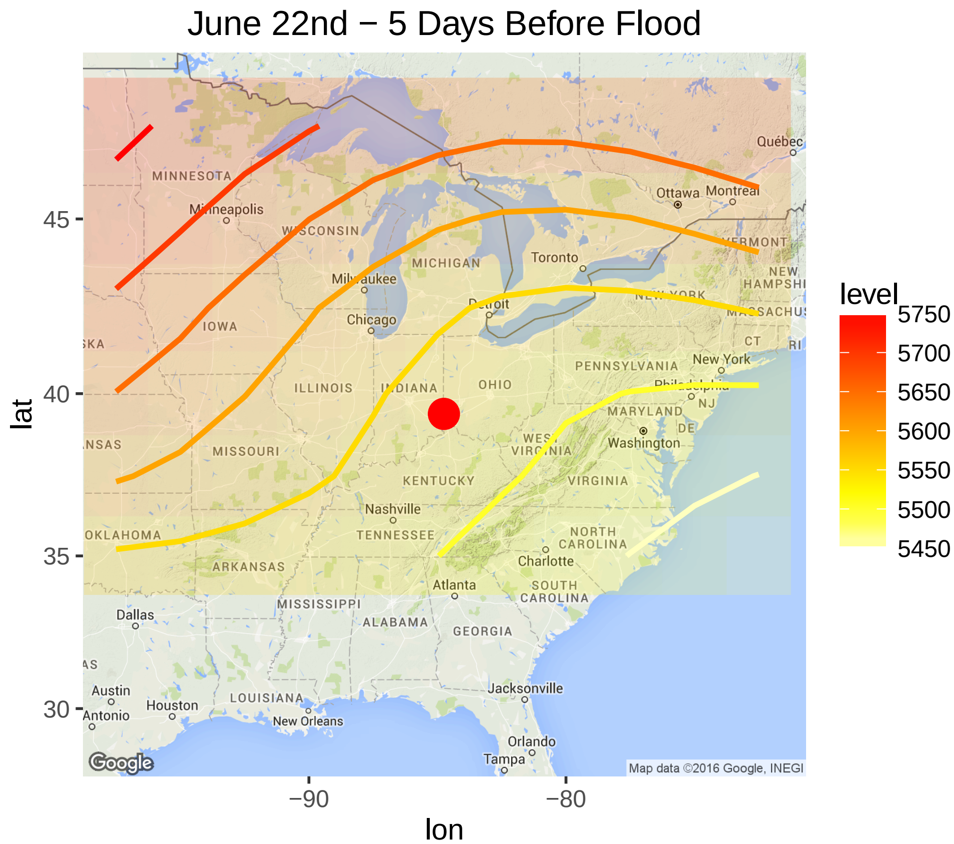




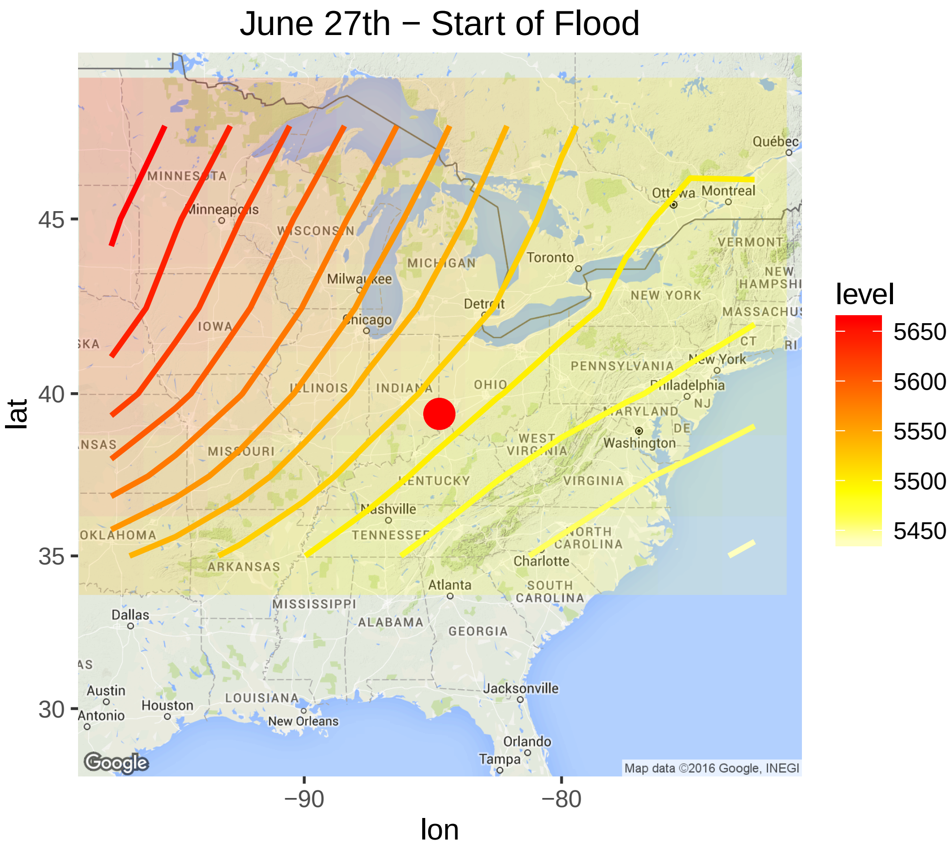
According to the plots, we can see that many floods occurred in the areas with lower pressure, detailed analysis will be illustrated below.

Pressure Distribution of Several Floods

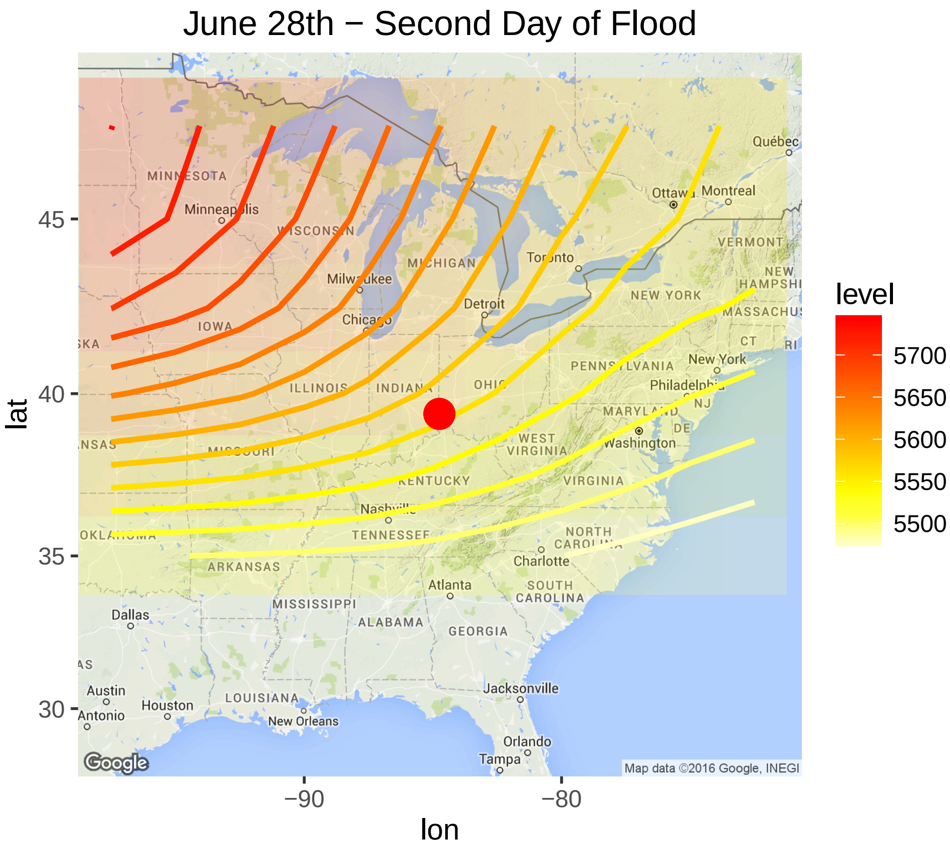
Firstly, we will focus on changes of contours during the flood that happened in the area of Southern Michigan, central Indiana, and western Ohiothe in the US from Jun 27, 2015 to Jun 29, 2015.



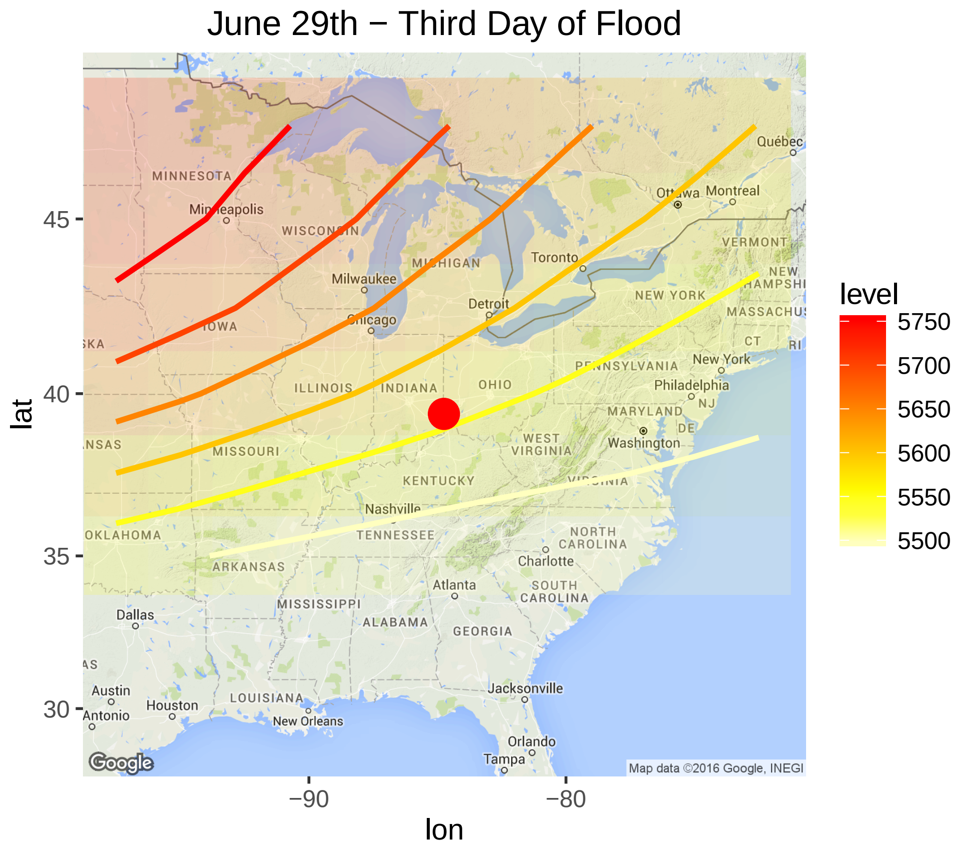
This is a contour map of pressures on Jun 22, 2015. We indicate where the flood happened with a red dot. Contour values are represented by the "level" bar on the right side of the map. For example, the area that has deep red has high pressure. We can see that pressures between each area is wide.



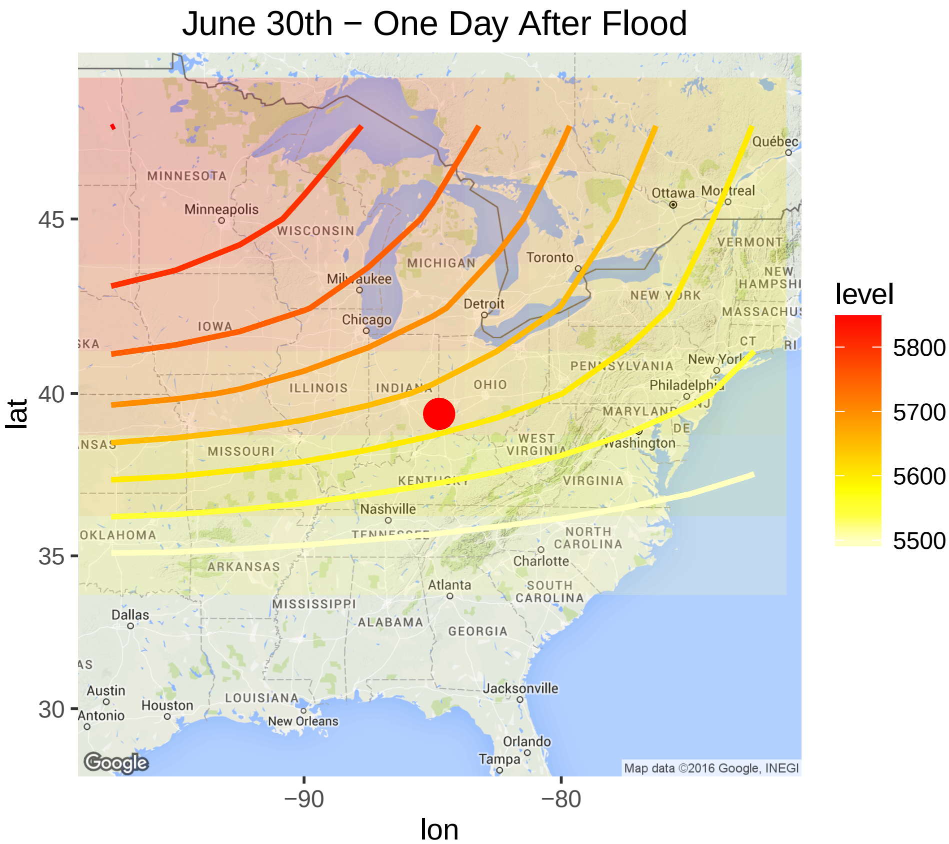
This is a contour map of pressures on Jun 27, 2015. As we can see, the are between each pressure band has narrowed; there is a high range of pressures in this area. Also, at the flood point, the pressure was approximately 5500.



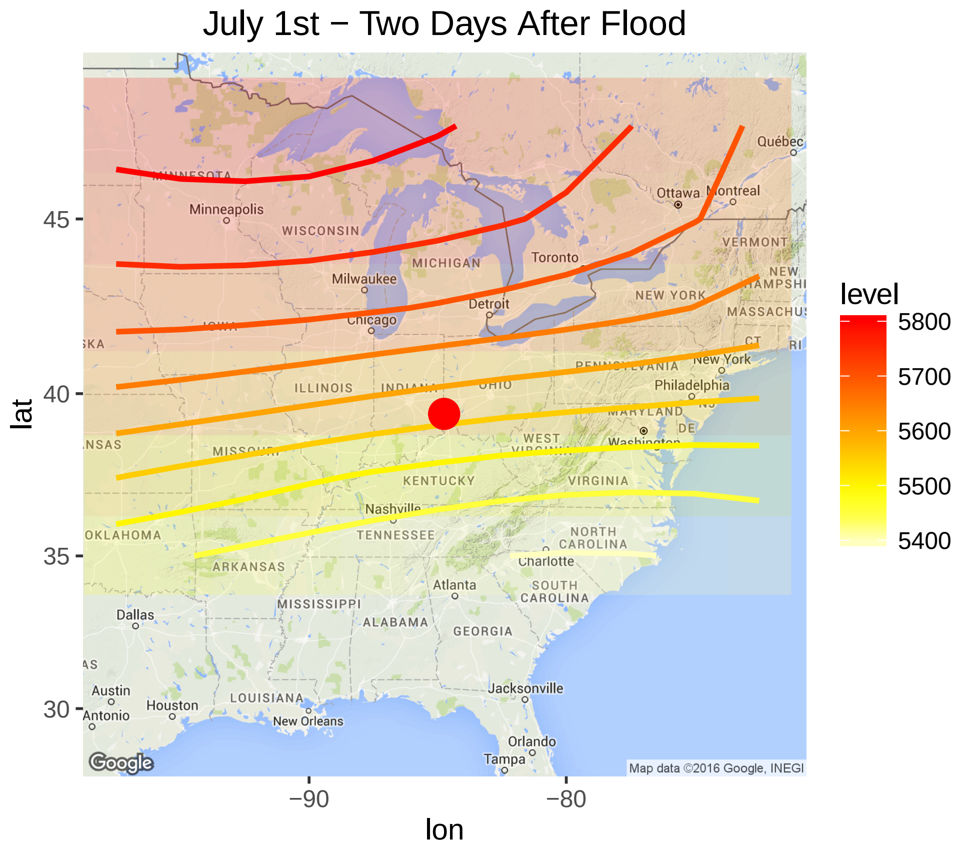
This is a contour map of pressures at Jun 28, 2015. Similar to the previous day, the pressure bands are very narrowly spaced. At the flood point, the pressure was around 5500.



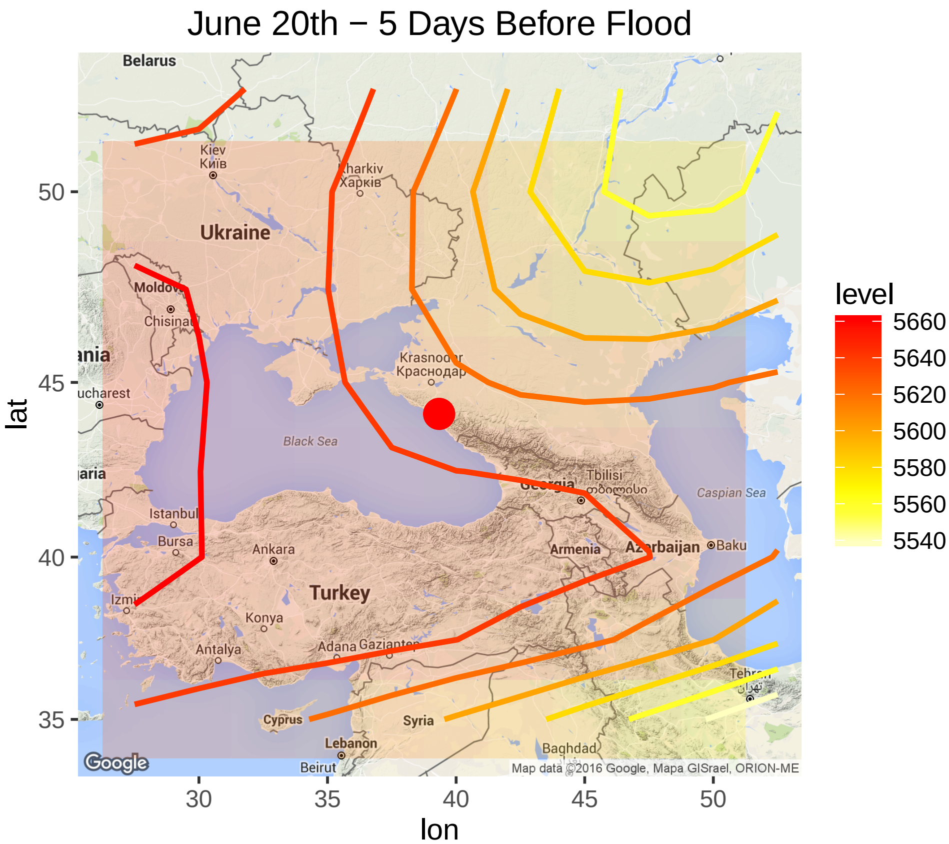
This is a contour information of pressures on Jun 29, 2015. Pressures between each area becomes wider. At the flood point, they had a value of the pressure that was around 5550.

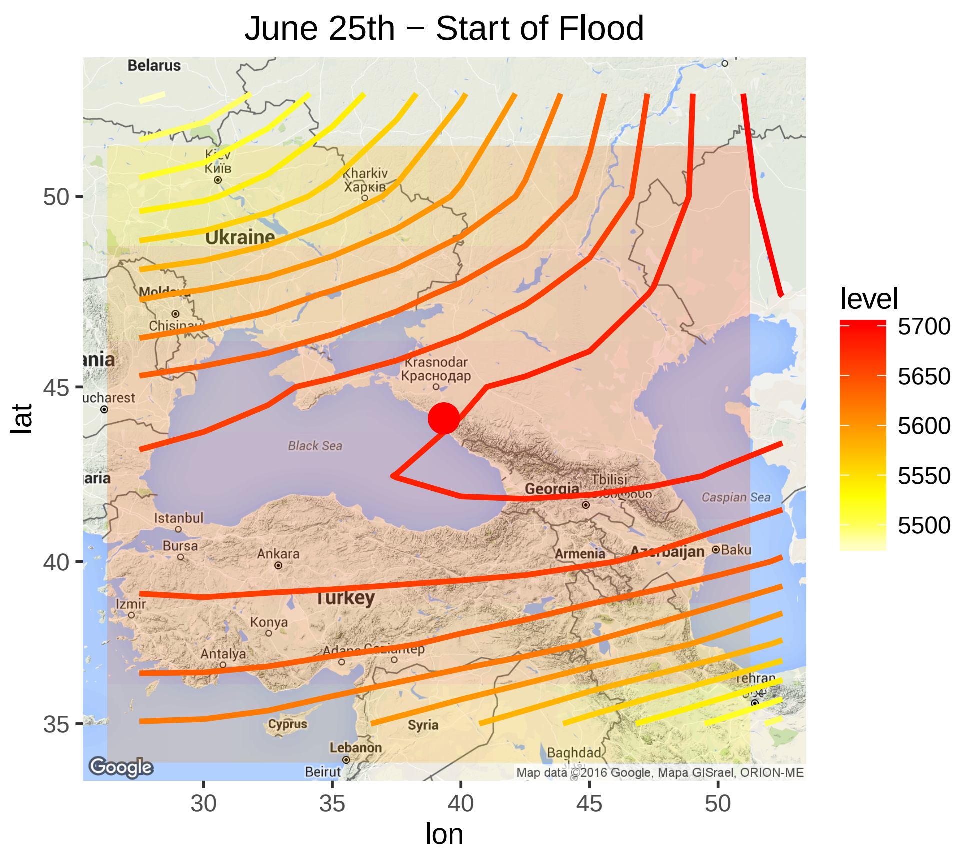


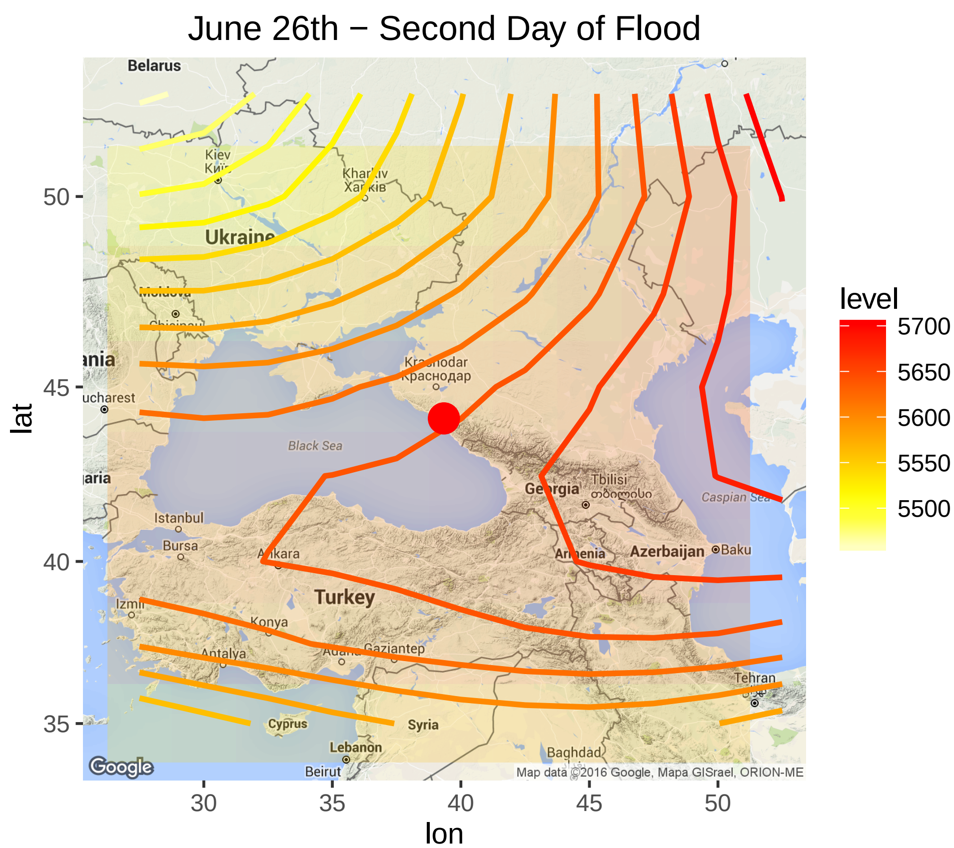
This is a contour map of pressures on Jun 30, 2015. It seems that there was a higher pressure value (around 5600) compared to when the flood was happening.

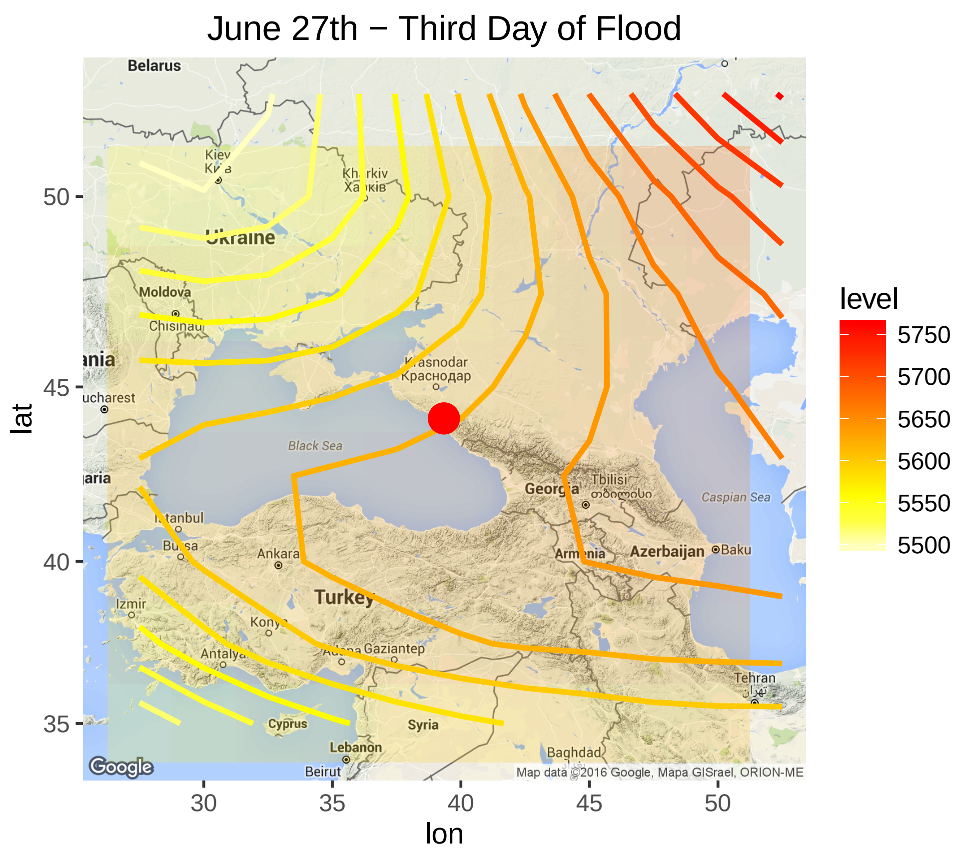


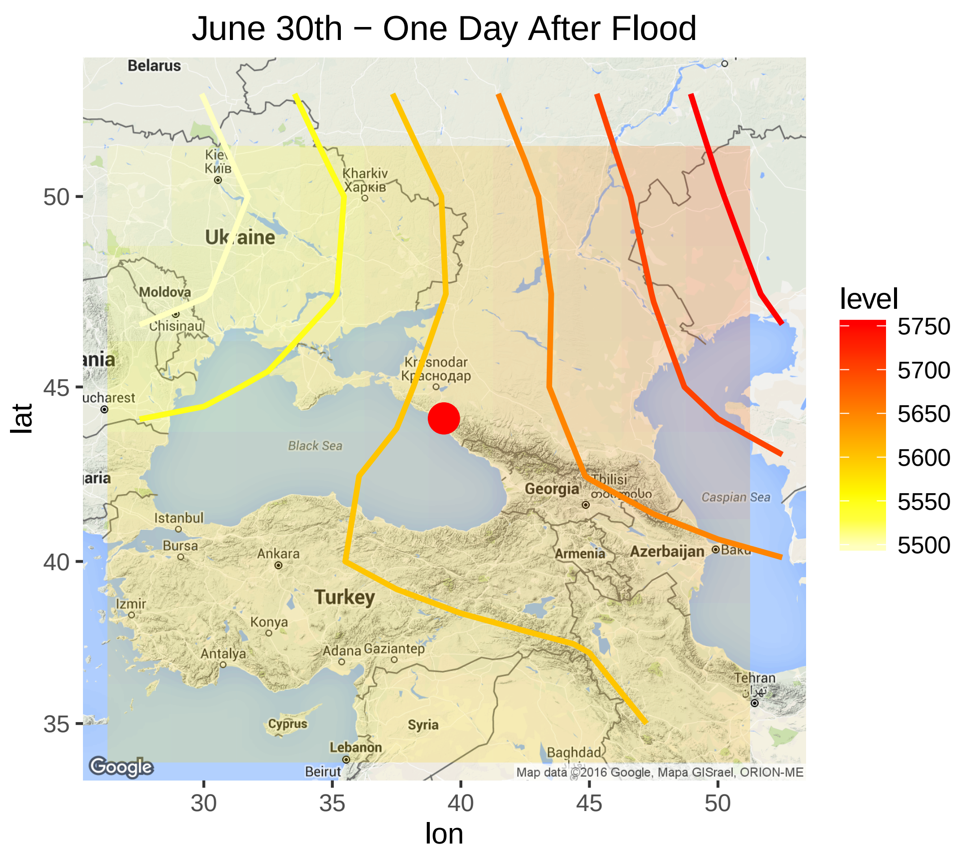
This is a contour map of pressures at July 1, 2015. Similar to the previous map, there was a higher pressure value (around 5600) compared to when the flood was happening.


June 20th − 5 Days Before Flood
lat
lon
level
5660
5640
5620
5600
5580
5560
5540
50
45
40
35
30
35
40
45
50
Belarus
Ukraine
Kiev
Київ
Kharkiv
Харків
Moldova
Chisinau
Bucharest
Krasnodar
Краснодар
Black Sea
Georgia
Tbilisi
თბილისი
Caspian Sea
Armenia
Azerbaijan
Baku
Istanbul
Bursa
Ankara
Turkey
Konya
Antalya
Adana
Gaziantep
Cyprus
Syria
Lebanon
Beirut
Baghdad
Tehran
Map data ©2016 Google, Mapa GISrael, ORION-ME

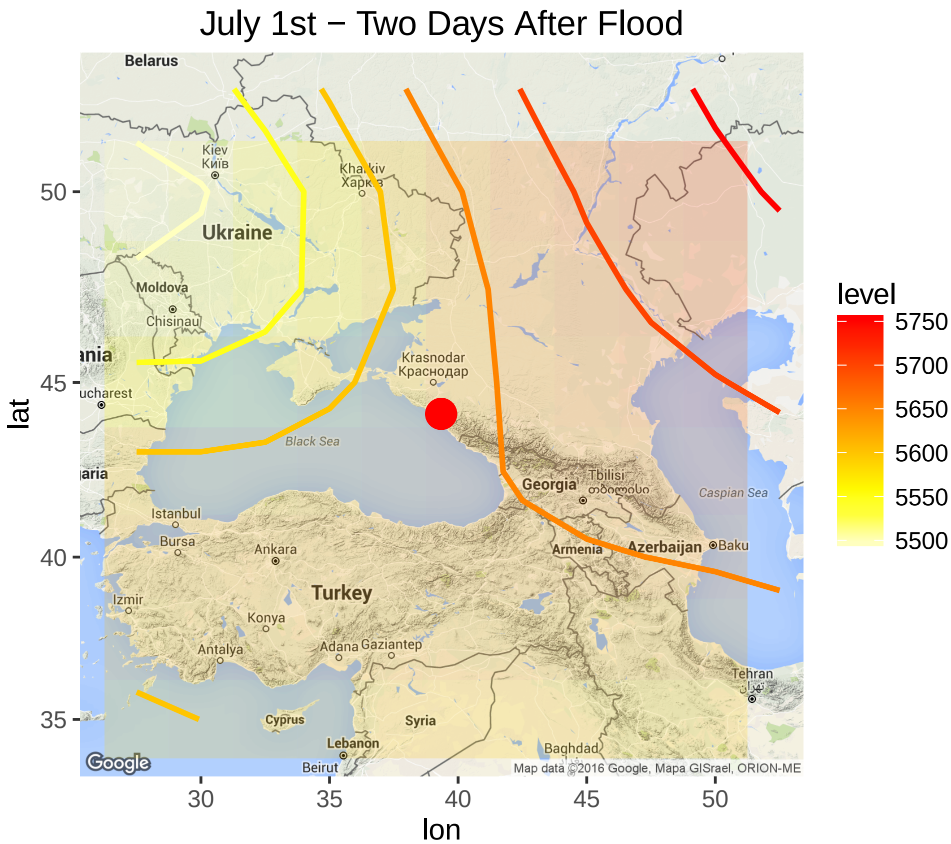

June 25th − Start of Flood
level
5700
5650
5600
5550
5500
lat
lon
50
45
40
35
30
35
40
45
50
Belarus
Ukraine
Turkey
Georgia
Armenia
Black Sea
Caspian Sea
Cyprus
Syria
Lebanon
Istanbul
Bursa
Ankara
Izmir
Konya
Antalya
Baku
Tbilisi
Krasnodar
Краснодар
Kharkiv
Харків
Baghdad
Beirut
Map data ©2016 Google, Mapa GISrael, ORION-ME


June 26th − Second Day of Flood
lat
lon
50
45
40
35
30
35
40
45
50
level
5700
5650
5600
5550
5500
Belarus
Kiev
Ukraine
Kharkiv
Moldova
Krasnodar
Краснодар
Bucharest
Black Sea
Istanbul
Bursa
Ankara
Turkey
Izmir
Konya
Antalya
Gaziantep
Cyprus
Syria
Lebanon
Beirut
Georgia
Tbilisi
Armenia
Azerbaijan
Baku
Caspian Sea
Tehran
Baghdad
Google
Map data ©2016 Google, Mapa GISrael, ORION-ME


June 27th − Third Day of Flood
lat
lon
level
5750
5700
5650
5600
5550
5500
50
45
40
35
30
35
40
45
50
Belarus
Ukraine
Moldova
Black Sea
Turkey
Georgia
Armenia
Azerbaijan
Caspian Sea
Syria
Lebanon
Cyprus
Istanbul
Ankara
Tbilisi
Baku
Tehran
Baghdad
Beirut
Map data ©2016 Google, Mapa GISrael, ORION-ME

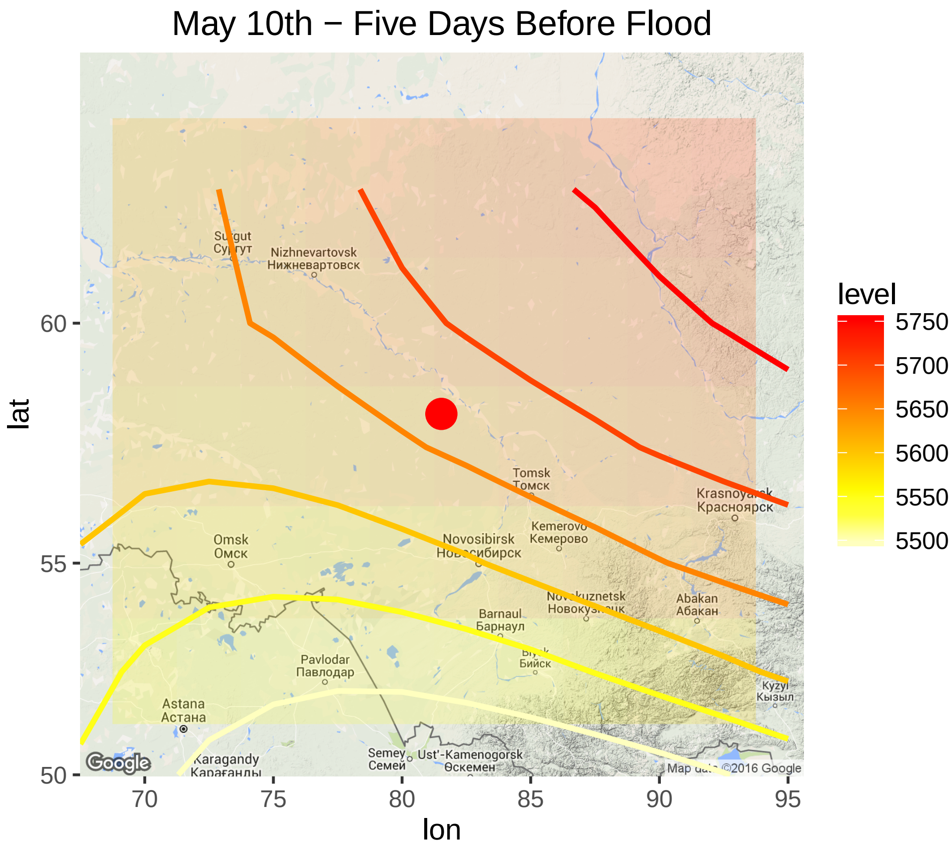


June 30th − One Day After Flood
level
5750
5700
5650
5600
5550
5500
lat
lon
50
45
40
35
30
35
40
45
50
Belarus
Ukraine
Moldova
Kharkiv
Krasnodar
Black Sea
Georgia
Armenia
Azerbaijan
Turkey
Istanbul
Bursa
Ankara
Izmir
Konya
Antalya
Adana
Gaziantep
Cyprus
Syria
Lebanon
Beirut
Baghdad
Tehran
Tbilisi
Baku
Caspian Sea
Chisinau
Map data ©2016 Google, Mapa GISrael, ORION-ME



Despite the different latitude and longitude, two floods in USA and Russia share many similarities. For example, five days before each flood happened, the pressure around the flood area increased to a level similar to the levels seen during the actual flood event.

Around the flood area, once the floods began, the pressure levels decreased. Also, it is notable that around the third day after the floods started, in both locations, the pressure decreased significantly and, by looking at the width between the contour lines around the flooded area, we can also notice that the gradient of the pressure is more pronounced. However, if we look at the contour of the pressure level 5 days after the floods ended, we can notice that interestingly, the pressure level increased a little bit, especially in USA, the pressure level was even higher than that before the flood happened.


May 10th − Five Days Before Flood
level
5750
5700
5650
5600
5550
5500
lat
lon
60
55
50
70
75
80
85
90
95
Nizhnevartovsk
Нижневартовск
Tomsk
Томск
Omsk
Омск
Novosibirsk
Kemerovo
Кемерово
Barnaul
Барнаул
Abakan
Абакан
Pavlodar
Павлодар
Astana
Астана
Karagandy
Semey
Семей
Ust'-Kamenogorsk
Өскемен
Google
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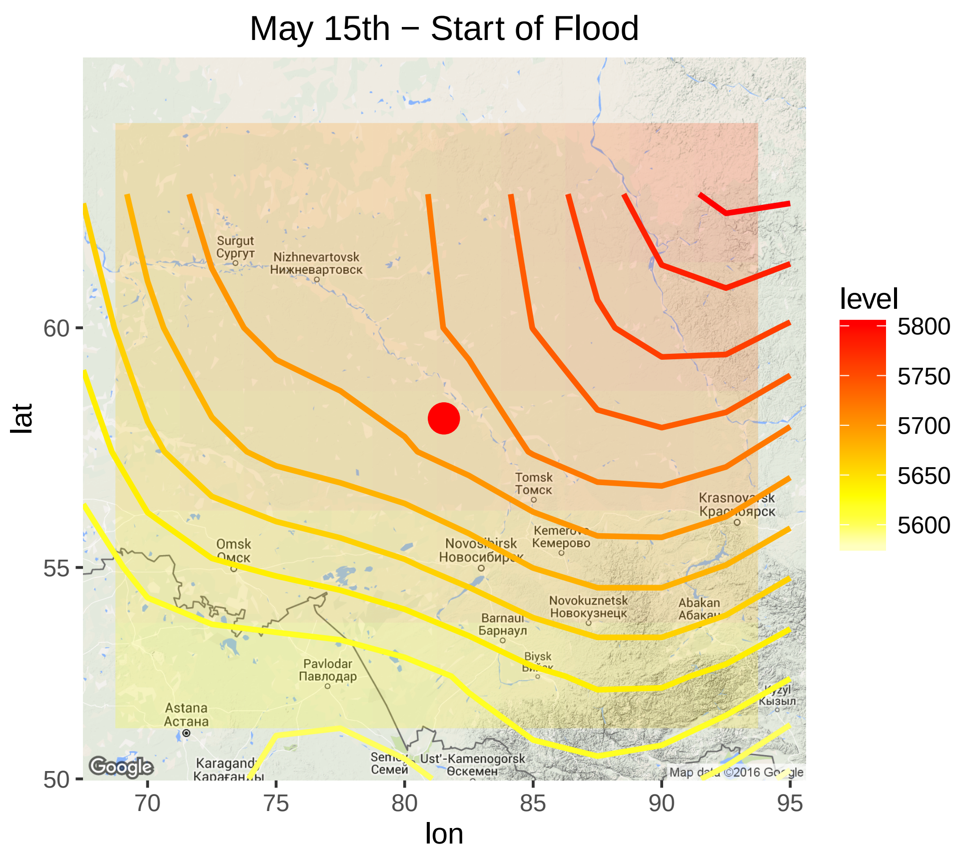
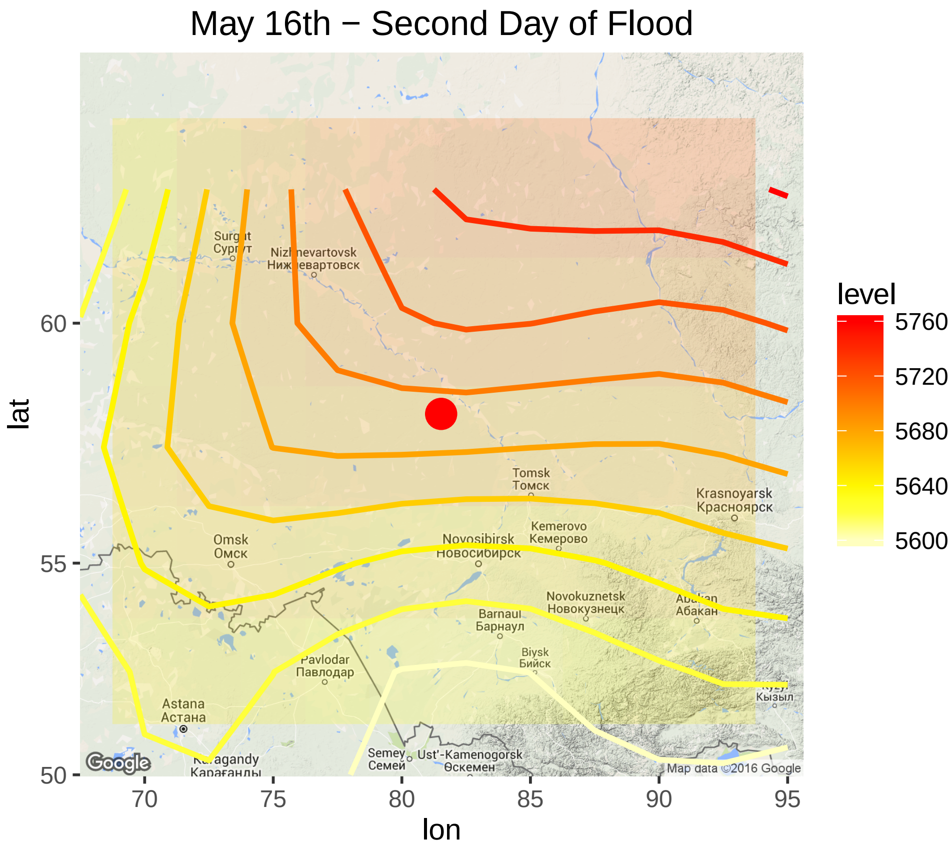
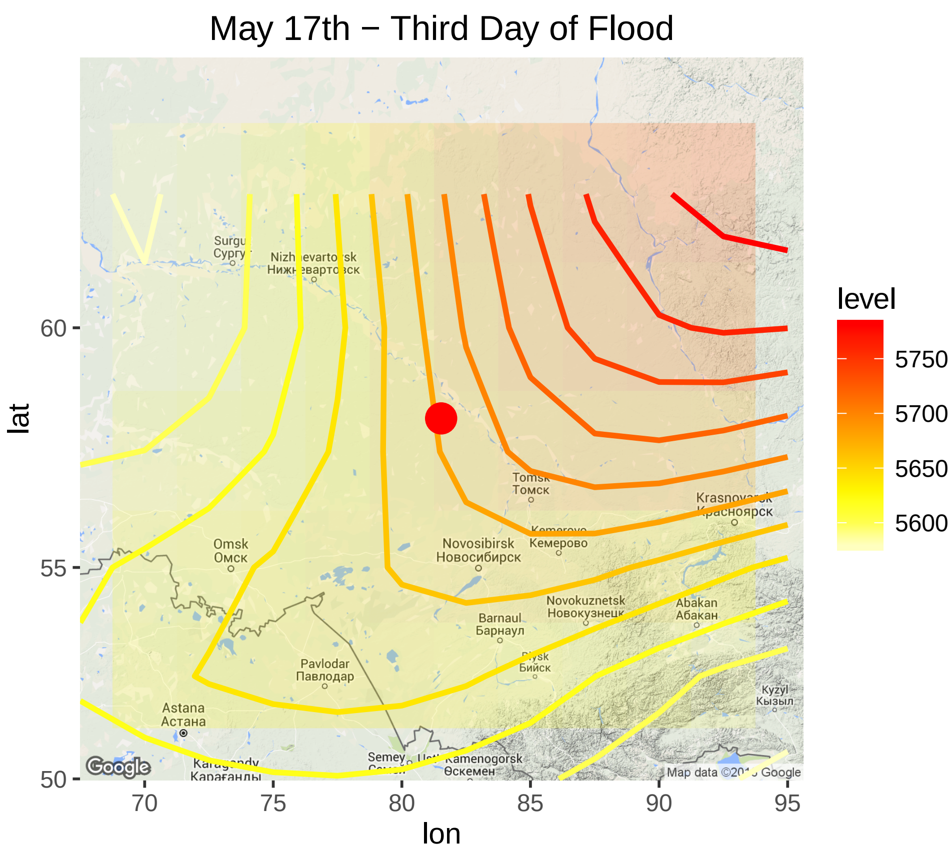
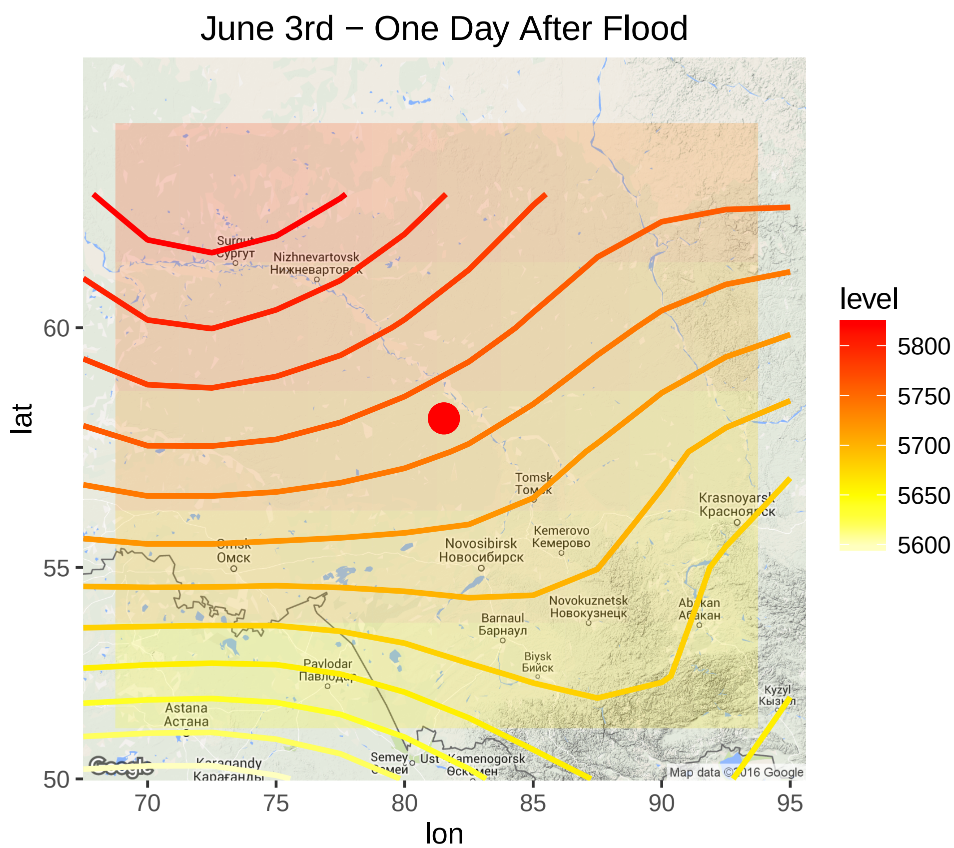
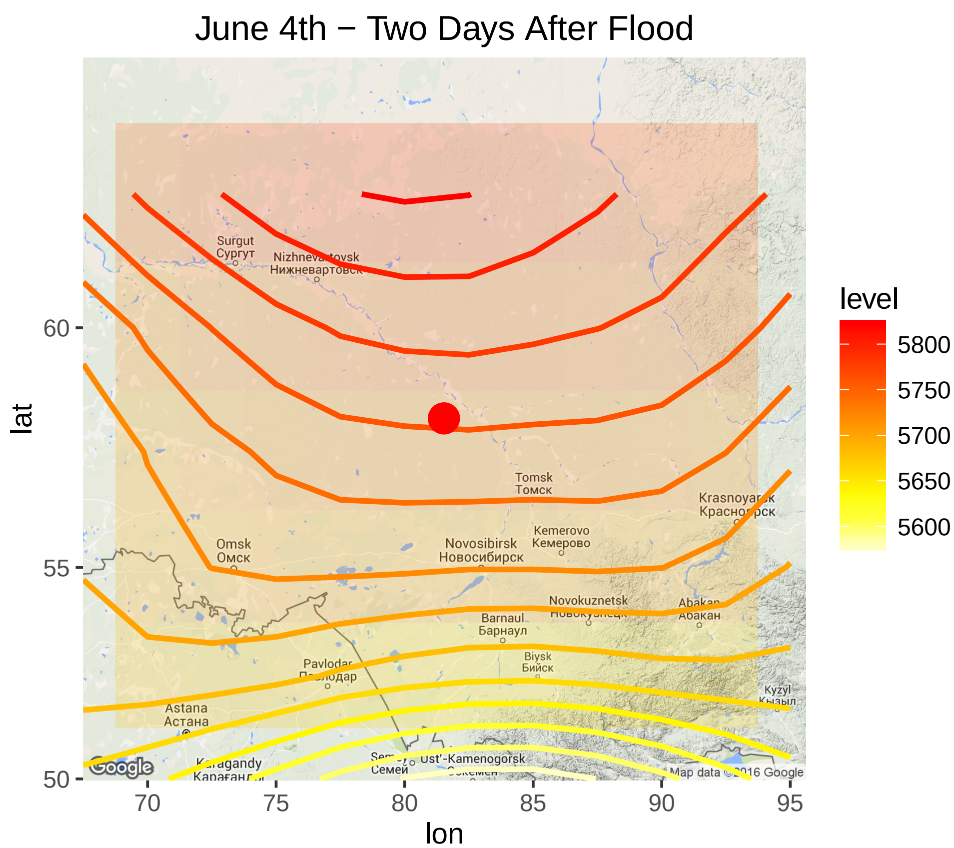

May 15th − Start of Flood
lat
lon
level
5800
5750
5700
5650
5600
60
55
50
70
75
80
85
90
95
Surgut
Сургут
Nizhnevartovsk
Нижневартовск
Tomsk
Томск
Omsk
Омск
Pavlodar
Павлодар
Astana
Астана
Novokuznetsk
Новокузнецк
Barnaul
Барнаул
Ust'-Kamenogorsk
Google



May 16th − Second Day of Flood
level
5760
5720
5680
5640
5600
lat
60
55
50
lon
70
75
80
85
90
95
Tomsk
Томск
Krasnoyarsk
Красноярск
Omsk
Омск
Novosibirsk
Новосибирск
Kemerovo
Кемерово
Novokuznetsk
Новокузнецк
Barnaul
Барнаул
Biysk
Бийск
Pavlodar
Павлодар
Astana
Астана
Semey
Семей
Ust'-Kamenogorsk
Өскемен
Map data ©2016 Google


May 17th − Third Day of Flood
level
5750
5700
5650
5600
lat
60
55
50
lon
70
75
80
85
90
95
Omsk
Омск
Novosibirsk
Новосибирск
Kemerovo
Кемерово
Tomsk
Томск
Barnaul
Барнаул
Novokuznetsk
Новокузнецк
Abakan
Абакан
Pavlodar
Павлодар
Astana
Астана
Kyzyl
Кызыл
Google
Map data ©2015 Google


June 3rd − One Day After Flood
lat
lon
level
5800
5750
5700
5650
5600
60
55
50
70
75
80
85
90
95
Nizhnevartovsk
Novosibirsk
Новосибирск
Kemerovo
Кемерово
Barnaul
Барнаул
Novokuznetsk
Новокузнецк
Pavlodar
Astana
Астана
Omsk
Омск
Biysk
Бийск
Map data ©2016 Google



The two floods we compared above both lasted around 5 days, so we decided to look at another flood with a much longer duration, in order to identify any significant differences in both absolute pressure level and pressure level change over time.

The above set of maps covers the pressure contours over a 2-week flood in Russia. Compared to the shorter Russian flood analyzed earlier, this long-lasting flood is actually quite similar. For example, on the fifth day before the flood happened, the pressure level had been very close to the peak level during the flood. Then, the pressure level decreased once the flood started, and on the fifth day after the flood had ended, the pressure level once again increased. The major difference between the pressure level during these two flood is that for the longer flood, the decrease in the pressure per day is less significant, which makes sense since the flood was still in the early stage and took longer to end.

PCA of Pressure Data

In performing PCA on the NOAA data, the pre-processing involved re-formating the data into an N x D matrix, such that: N = days, and D = lon x lat coordinates. Specifically, our goal was to do PCA over the USA, during the months of June and July, 2015 (to examine the floods covered in the above section).

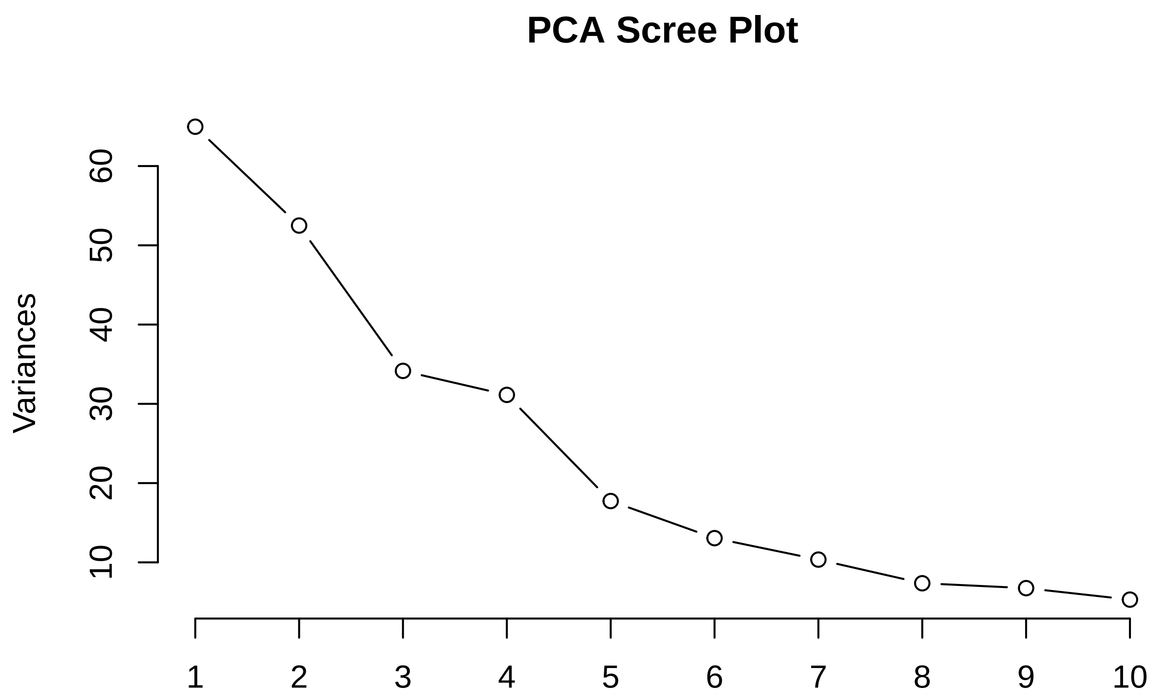
In this case, focusing on a specific location and timeframe was the only way to make PCA both intelligible and computationally feasible. Per the NOAA protocol, time is defined in days since 1/1/1948, so in this case, analyzing June-July 2015 corresponds with days 24624 to 24683. With regards to geography, the longitude and latitude will be bounded by: 230-300 Degrees East, and 25-55 Degrees North, respectively.

Doing the PCA itself involved centering and scaling each "grid" of longXlat data (in order to standardize the PCA). Here is the summary output of the PCA, focusing on the first 10 Principal Components:

```
## Importance of components:
```

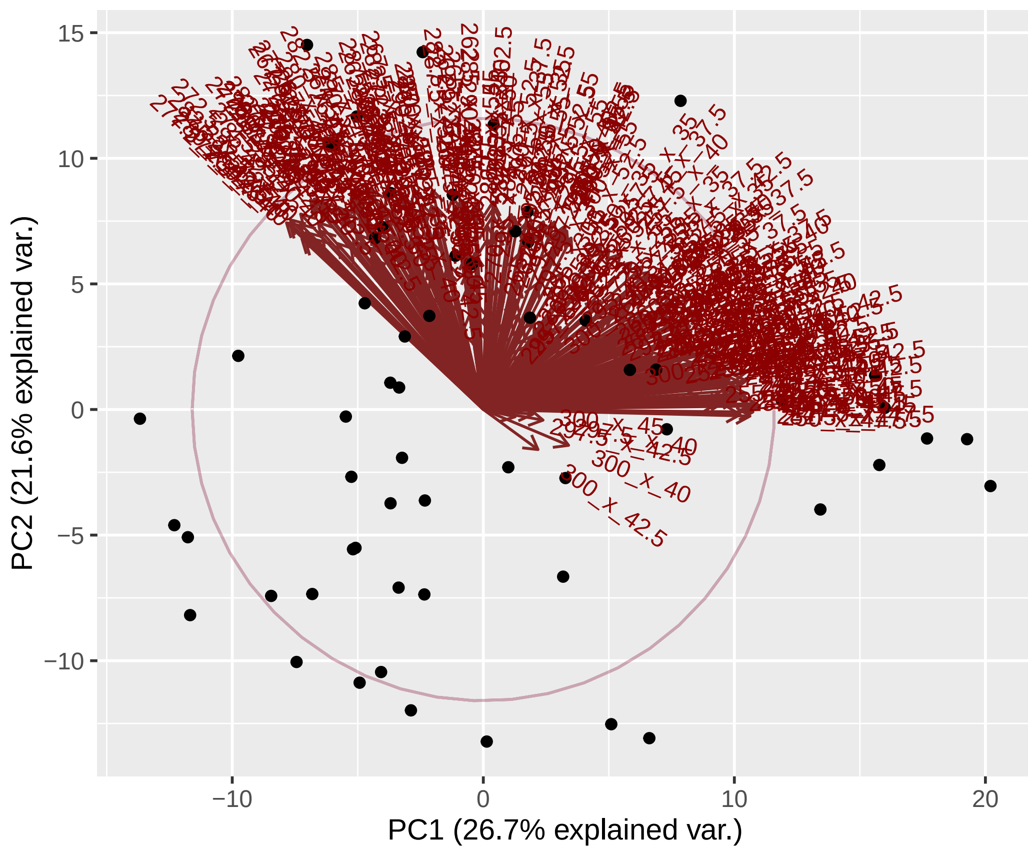
```
##                           PC1    PC2    PC3    PC4    PC5     PC6     PC7
## Standard deviation     8.060 7.2453 5.8443 5.5795 4.2113 3.61319 3.21658
## Proportion of Variance 0.267 0.2158 0.1404 0.1280 0.0729 0.05366 0.04253
## Cumulative Proportion  0.267 0.4828 0.6232 0.7511 0.8240 0.87769 0.92022
##                            PC8     PC9    PC10
## Standard deviation     2.71364 2.59776 2.30177
## Proportion of Variance 0.03027 0.02774 0.02178
## Cumulative Proportion  0.95048 0.97822 1.00000
```

This is a Scree Plot showing the relative importance of the first 10 PCs.



Finally, we used the ggbiplot package to build an interesting, though dense, biplot of the PCA data.

```
## Skipping install for github remote, the SHA1 (7325e880) has not changed since last install.
##   Use `force = TRUE` to force installation
```


PC2 (21.6% explained var.)
PC1 (26.7% explained var.)
15
10
5
0
−5
−10
−10
0
10
20
300_x_45
300_x_40
300_x_42.5